This project has received funding from the European Union's H2020 Coordination Support Action under Grant Agreement No. 894356.

Best Practice	REDUCTION OF LEAKAGES	CAIR-07
Application	Compressed Air Systems	
SME sector	Industrial	
SME Sub-sector	Food and Beverage Sector	

Technical description

Compressed air: versatile and energy-intensive

Compressed air is used for a large variety of applications, e.g., for powering pneumatic tools or as process medium directly used in production. On average, compressed air generation is responsible for about 10% of electricity demand in industrial companies. Electricity costs are an important aspect of compressed air usage since they easily hold a share well above 70% of the costs of an optimized compressed air station over a period of five years. According to estimates, energy demand at a nominal flow rate and a typical pressure of 7 bar is between 85 to 130 Wh per Nm^3 of compressed air for a correctly dimensioned and well managed installation. This typically translates into some 1 to 3 Eurocents per Nm^3 of compressed air, depending on the system performance and electricity prices.

Air leaks are tireless consumers of compressed air, even after office hours and during the ends. Even small leaks can entail substantial losses in electrical energy and may thus cause substantial energy costs. Dealing with them is often quite easy and a regular check on leaks is thus a good strategy to both minimize electricity costs and save money.

Reducing air leaks to save money

A usually easy to implement and cheap measure for normal operation is the reduction of air leaks. These have been identified as major sources of energy losses in compressed air systems.

They originate from badly carried out installation work, worn equipment or a lack of sensitivity from the user, e.g., from semi-shut air valves.

A particular challenge with air leaks is that they are always present in a compressed air system under pressure, even during the weekend when nobody is working. Thus, avoiding leaks can result in an average reduction of electricity demand for compressed air provision between 10 and 20% of the total energy demand of a compressed air system

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Air leak occurrence & detection

Air leaks may occur in all parts of a compressed air system, from air compressor to the end-use including:

- Couplings, fittings and valves
- Pipe joints, disconnections
- Pressure regulators and condensate traps
- Tools and pneumatic equipment

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<tr><td>Recommendation for optimisation</td><td>

A reasonable goal for reducing leakages is 10% of the demand. Systems with 5% of the demand are excellent. Further reduction leads in most cases to unreasonably high investment or maintenance costs and are thus not economically viable.

The best way to find the location of leakages is by using special ultrasound devices. The advantage of this equipment is that it can be used when production is full running. During production breaks or during the night shift when there is no noise it is possible to detect bigger leakages without equipment. Another way to check for leakages is to apply soap water onto the pipes, couplings and valves.

Especially flexible and connecting parts are a common source for leakages:

- couplings: cheap quick-lock couplings made of brass show a high potency for
- pipes or sealing parts: PVC-pipes can harden, seals made of hemp often dry out when switching to oil-free air or replacing dryers
- pneumatic components: loose and leaking connection parts, damaged oil separators, leaking valves
- cylinder: old seals or connecting parts of cylinders, leakages inside the pneumatic tools

To eliminate the leakages, the following measures can be done:

- Tightening of cutting ring coupling
- Replacement of thread sealing (Teflon tape or liquids)
- Replacement of valves, cylinders, couplings and seals
- Replacement of damaged or corroded pipes

Every company should be checking the systems at least once a year. This can be done internally or externally. Time and resources should always be provided to be able to fix located leakages immediately.
There is a variety of ways to detect or reduce air leaks:

- Especially larger leaks make audible noise and/or can even be felt in the near proximity
- The use of soapy water applied with a paint brush used on suspect areas can be an easy mean to identify leaks
- Leaks lead to ultrasonic sound emissions. The market offers acoustic detectors which can help to also localize such emissions from smaller leaks
- Leaks can also be traced using particular gases

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	Another strategy to deal with air leaks is separating of parts of the compressed air network while production is not running, e.g., by automated valves or by adding manual switches, e.g., for idle times during the week-ends. This can also be a strategy if leaks are difficult to localize or fix.
Relevant technical considerations	Compressed air systems can be subject to leakages of up to 20% of the compressed air produced over time. These types of systems also have a significant impact on an industry's energy costs, as producing 1 kW of compressed air costs the same as producing 8 kW of electricity. Reducing or eliminating compressed air leakages therefore represents a significant energy saving and a reduction in plant costs.
Schemes and diagrams	(see table below)

Hole diameter (mm)	Air leakage at 6 bars (l/s)	Air leakage at 12 bars (l/s)	Energy at 6 bars (kWh)	Energy at 12 bars (kWh)	Costs at 6 bars (EUR)	Costs at 12 bars (EUR)
1	1,2	1,8	0,3	1,0	144	480
3	11,1	20,8	3,1	3,1	1488	6096
5	30,9	58,5	8,3	33,7	3984	16176
10	123,8	235,2	33,0	132	15840	63360

Economics	Typical costs for leak research and repair are approx. 1,000 EUR/year. Material costs for repair: on average between 20 and 50 EUR, large deviations are obviously possible. Labour costs: varies depending on the cause of the leakage Depending on the situation and strategy, detecting and fixing leaks is nearly free, yet can have a substantial impact on energy costs. For instance, fixing a 3 mm leak with 3 kW in power requirement under 3,000-hour operation leads to annual savings in electricity costs of: 3kW x 3,000h/y x 0.1 EUR/kWh = 900 EUR/year
Energy savings	Annual savings per fixed 3 mm leak 9,000 kWh/year Average reduction of electricity demand for compressed air provision between 10 and 20% of the total energy demand of a compressed air system
Economic savings	Annual savings per fixed 3 mm leak 900 EUR/year One single leak with 1mm in diameter in a system with 8 bar pressure can cause additional costs of 150 EUR/year. Saving potential of 6-10% per bar

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Average Payback Time	Less than 3 years	
Emissions	This measure does not lead to further emissions	
Environmental benefits	Reduction of CO_2 emissions due to lower energy needs.	
Main NEBs (Multiple benefits)	☒ Environmental benefits ☐ Increased productivity ☒ Work environment/ Health/Safety ☐ Increased competitiveness ☐ Maintenance	The more stable pressure supply can lead to an increase in the quality of the products. Fixing leakages can lead to a reduction of the noise level
Replicability	High In almost all compressed air systems – in 80% of systems this measure is applicable and cost-effective	
Related measures	• CAIR-01: Optimisation of compressed air users/appliances • CAIR-02: Optimisation of the pressure in the system • CAIR-03: Switch-off of appliances in non-operational times • CAIR-04: High Level Control • CAIR-05: Sizing and type of compressor • CAIR-06: Network Optimization • CAIR-08: Heat recovery	
Case study	Case study #1 Publishing sector: reducing energy waste from a compressed air service (Bologna, Emilia-Romagna, Italy) • Initial Situation: Leakages occurring in the system. Scope: to reduce energy waste due to compressed air leaks in a 9,000 m^2. Analysis carried out: inspection of compressed air system components: Compressors, Distribution network (including piping and connections), Terminal equipment and compressed air installations. A parabolic directional sensor with a laser pointer was used to detect leaks at heights above 2.5 m or in places difficult to reach.	

Number of leaks found	Leakage m^3/h	Leakage in m^3/year	Leakage in kWh/year	Leakage in EUR/year
48	175	211,600	1,511,300	30,050

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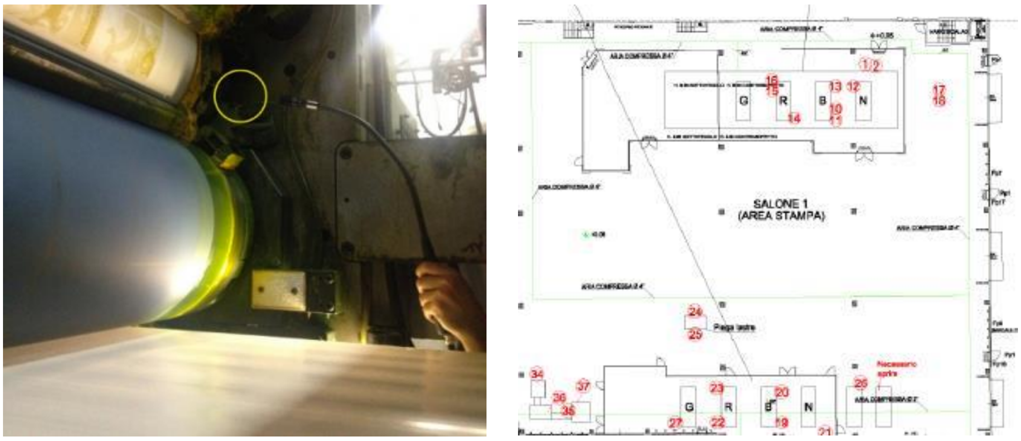
The research campaign revealed a limited number of leaks, but a significant total, concentrated mainly in the rotary presses department (30 leaks out of a total of 48, corresponding to approximately EUR 20,000 in electricity consumption) and also present during machine downtimes. It was estimated that the energy waste due to leaks exceeds 20% of the total compression energy cost.

- Description of the optimisation: Repair/replacement campaign for defective parts, giving priority to the rotary zones.



Detail of the factory floor plan showing the location of the detected leaks.

- Implementation costs: starting from 0 EUR, very low investment
- Payback Time: less than 1 year

Case study #2

Mechanical sector: reducing energy waste from a compressed air service (Parma, Emilia-Romagna, Italy)

- Initial situation: Leakages occurring in the system.
  To reduce energy waste due to leaks from the compressed air system in a 19,000 m^2 plant belonging to a company in the mechanical sector with a foundry division Analysis carried out: inspection of compressed air system components: Compressors, Distribution network (including piping and connections), Terminal equipment and compressed air installations.
  A parabolic directional sensor with a laser pointer was used to detect leaks at heights above 2.5 m or in places difficult to reach.

Number of leaks found	Leakage m^3/h	Leakage in m^3/year	Leakage in kWh/year	Leakage in EUR/year
122	291.4	932,580	130,560	20,630

The research campaign showed that the compressors were in good condition, with no air leaks at the source. As regards the foundry area, most of the leaks were found along the pipes, often at high altitude. These leaks are in general of

	medium/difficult elimination. In the workshop area most of the leaks are at quick couplings and deteriorated connections, therefore generally easy to eliminate. • Description of the optimisation: Replacement of identified faulty connections. For the foundry area: repair of the pipes, starting with those that are easy to access. A second campaign was recommended at the end of the interventions to verify the effective elimination and scope of the remaining leaks. • Implementation costs: starting from 0 EUR, very low investment • Payback time: less than 1 year
References	Kulterer, K., Huber J., Ruthner H., Oetiker H., Pucher C., Steinbrugger, C.: Leitfaden für Energieaudits zur Optimierung von Druckluftsystemen, klimaaktiv energieeffiziente betriebe, Wien 2015 Larrabee C.: Managing Multiple-Compressor Systems: Utilizing Controls to Improve Performance 3E Strategy, Department of Mechanical engineering, University of cape town: How to save energy and money in compressed air systems ICCEE, Energy efficiency measures: best practices: https://iccee.eu/energy-efficiency-measures-best-practices/ https://www.enea.it/it/seguici/events/sistemiariacompressa_14mag19/MARINOZZIFATER.PDF Fraunhofer ISI, Druckluft effizient, October 2003 U.S. Department of Energy Washington, Energy Efficiency & Renewable Energy - Office of Industrial Technologies, Compressed Air Tip Sheet #3. December 2000. Publications Office of the European Union, Best Available Techniques (BAT) Reference Document for Energy Efficiency. 2009.

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